NASA CR-161, 442

NASA-CR-161442

19800017287

A Reproduced Copy

OF

NASA CR-161, 442

Reproduced for NASA

by the

NASA Scientific and Technical Information Facility

FFNo 672 Aug 65

(NASA-CR-161442) SOLAR HEATING AND COOLING DEMONSTRATION PROJECT AT RADIAN CORPORATION, AUSTIN, TEXAS Final Report (Radian Corp.) 41 p HC A03/MF A01 CSCL 10A

N80-25784

Unclas
G3/44 22398

DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-161442

SOLAR HEATING AND COOLING DEMONSTRATION PROJECT AT RADIAN CORPORATION, AUSTIN, TEXAS - FINAL REPORT

Prepared by

Radian Corporation
8500 Shoal Creek Boulevard
P. O. Box 9948
Austin, Texas 78766

Under DOE Contract EX-76-C-01-2396, U. S. Department of Energy

Monitored by

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

U.S. Department of Energy

Solar Energy

N80-25784 #

BEST

AVAILABLE

COPY

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. DOE/NASA CR-161442	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Solar Heating and Cooling Demonstration Project at Radian Corporation, Austin, Texas - Final Report		5. REPORT DATE May 1980 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS Radian Corporation 8500 Shoal Creek Boulevard P. O. Box 9948 Auxtin, Texas 78766		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO. EX-76-C-01-2396
12. SPONSORING AGENCY NAME AND ADDRESS U. S. Department of Energy Conservation and Solar Energy Washington, DC 20585		13. TYPE OF REPORT & PERIOD COVERED Contractor Report Final 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This work was done under the technical management of Mr. William A. Hagen, National Aeronautics and Space Administration, Marshall Space Flight Center, Alabama.

16. ABSTRACT

This document is the final technical report of the solar energy facility located at the Radian Corporation, Austin, Texas, 78766. This system has been operational since April, 1977. Major components of this system include 36 Northrup collectors, a 1500 gallon fiberglass thermal storage tank, an ARKLA absorption cooling unit and cooling tower, a Servel heating coil, pumps, heat exchanger, and a conventional back-up heating and air conditioning unit. System controls consist of a dual-stage thermostat, a control panel, a differential temperature controller, and three absolute temperature controllers. The system is designed to operate in several modes with evaluation of each mode. System performance monitoring is accomplished through 47 sensors which are sampled and recorded every five minutes by a data acquisition system. An on-site-monitor test set allows instantaneous testing and evaluation.

This report also references Monthly Performance Reports, A Solar Energy System Performance Evaluation Report, A Solar Project Cost Report and A Solar Project Description Report for this site which are available through the National Technical Information Service.

17. KEY WORDS	18. DISTRIBUTION STATEMENT UC-59a Unclassified - Unlimited WILLIAM A. BROOKSBANK, JR. Mgr., Solar Energy Applications Projects

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	37	NTIS

MSFC - Form 3292 (Rev. December 1972)

For sale by National Technical Information Service, Springfield, Virginia 22151

RADIAN CORPORATION

TABLE OF CONTENTS

PRECEDING PAGE BLANK NOT FILMED

TABLE OF CONTENTS
(Continued)

1.0 INTRODUCTION

Radian Corporation under a contract with the Department of Energy designed and installed a solar heating and cooling system for part of its office complex located at 8500 Shoal Creek Boulevard in Austin, Texas. This report is the final report for this demonstration project as required by Contract Number EX-76-C-01-2396.

Radian's solar system has been operational since February 1977. A public ceremony was held in April of 1977 to allow visitors and guests to have a guided tour of the solar system and to allow NASA representatives to address the audience. Since that time Radian has provided numerous tours and demonstrations to the general public including classes from schools, colleges and universities, civic groups, clubs, and individual visitors.

During the last three years Radian has maintained the system and the acceptance tests on the system were conducted in November 1979. The system has had only minor problems with the exception of the collector tracking mechanism. Several periods of extended down time were caused by tracking mechanism failures. While Northrup has modified the tracking mechanism design, the most frequent problems are still associated with the tracking mechanism.

This report is split into two sections. Section 2.0 presents the technical description of the solar system while section 3.0 presents the costs of the major components and the cost of installing the system. Since drafting costs were not permitted on this contract, engineering drawings are not available. However, flow diagrams and photographs of the solar system are presented in place of the as-built drawings.

2.0 RADIAN SOLAR HEATING AND COOLING SYSTEM DEMONSTRATION PROJECT

2.1 System Components

A block diagram of Radian's solar heating and cooling demonstration system is shown in Fig. 1. The major components of this system include 36 Northrup collectors, a 1500 gal thermal storage tank, an ARKLA absorption cooling unit and cooling tower, a Servel heating coil, pumps, heat exchanger, and a conventional back-up heating and air conditioning unit. Figures 2, 3, 4, and 5 show some of the system components that are described below.

2.1.1 Collectors

The Northrup collectors shown in Fig. 6 use a 1-foot by 10-foot Fresnel lens to concentrate sunlight (direct insolation) onto a flattened copper absorber tube that has a black chrome coating to enhance the absorption of solar energy. Like most concentrating collectors, a tracking mechanism is required to constantly focus the sunlight onto the absorber tube. Each collector has a pulley attached to the shaft at the lower end. A steel cable that is looped around each collector pulley simultaneously rotates up to twenty collectors. A pair of photovoltaic cells are used to sense the location of the sun. An unbalanced output from these cells will turn on a motor which rotates the collectors via a gear box and the cable. When the output of the photovoltaic cells is again balanced, the tracking motor will stop and maintain this position until an unbalance arises.

The collectors, of course, track the sun's east-west path. In addition, the collectors are tilted 30° (Austin's

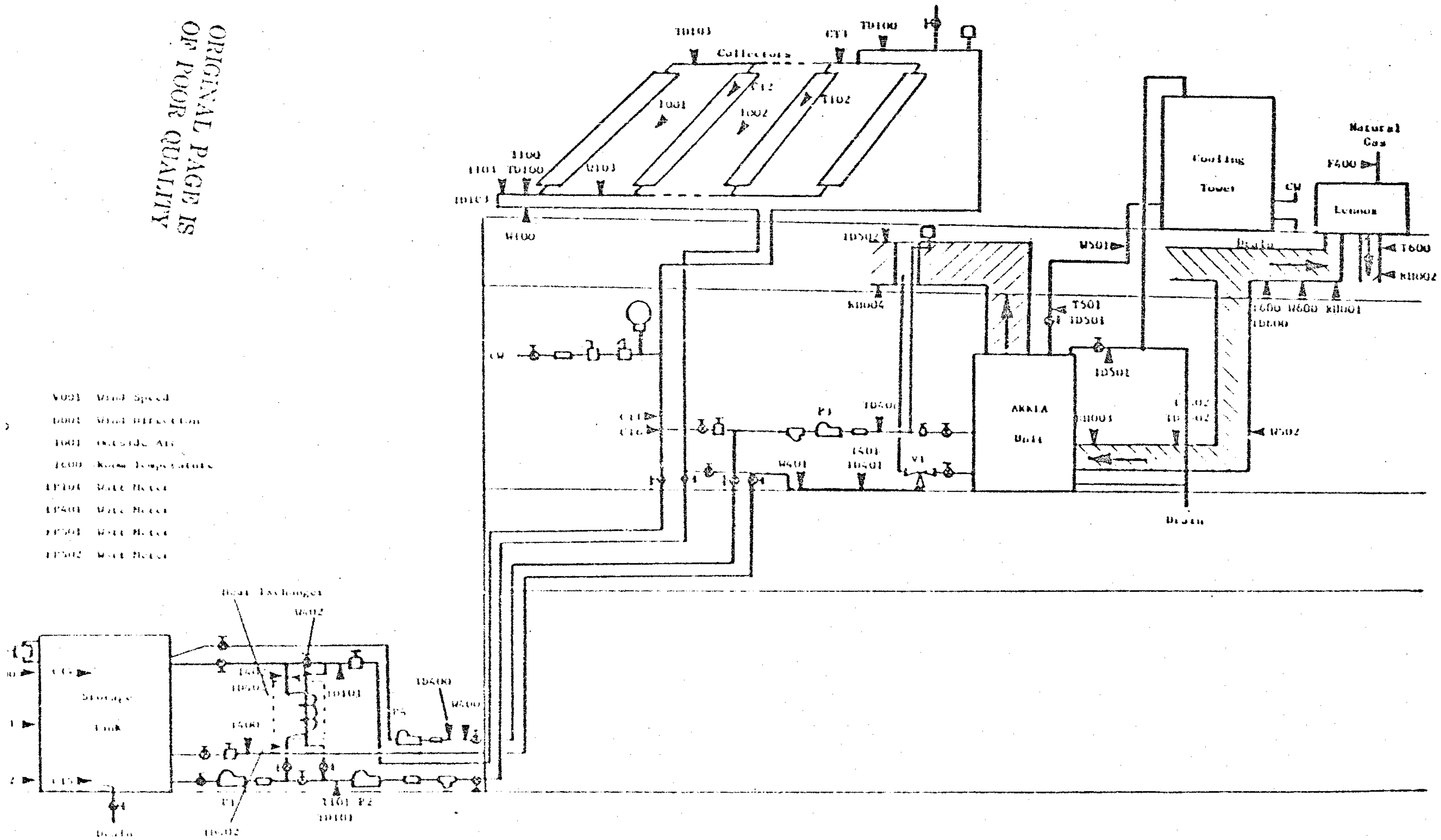

Fig. 1. Radian Corporation Solar Demonstration Project
Flow Diagram and Monitoring Sensor Location

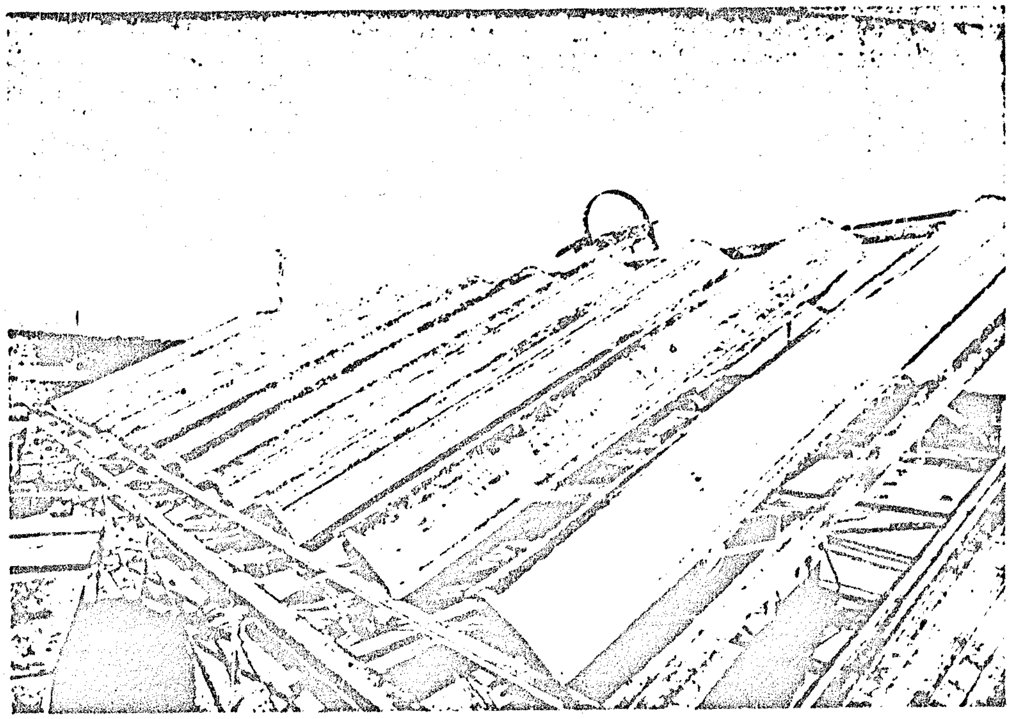

Fig. 2. Concentrating Solar Collectors
(North Bank)

RADIAN
CORPORATION

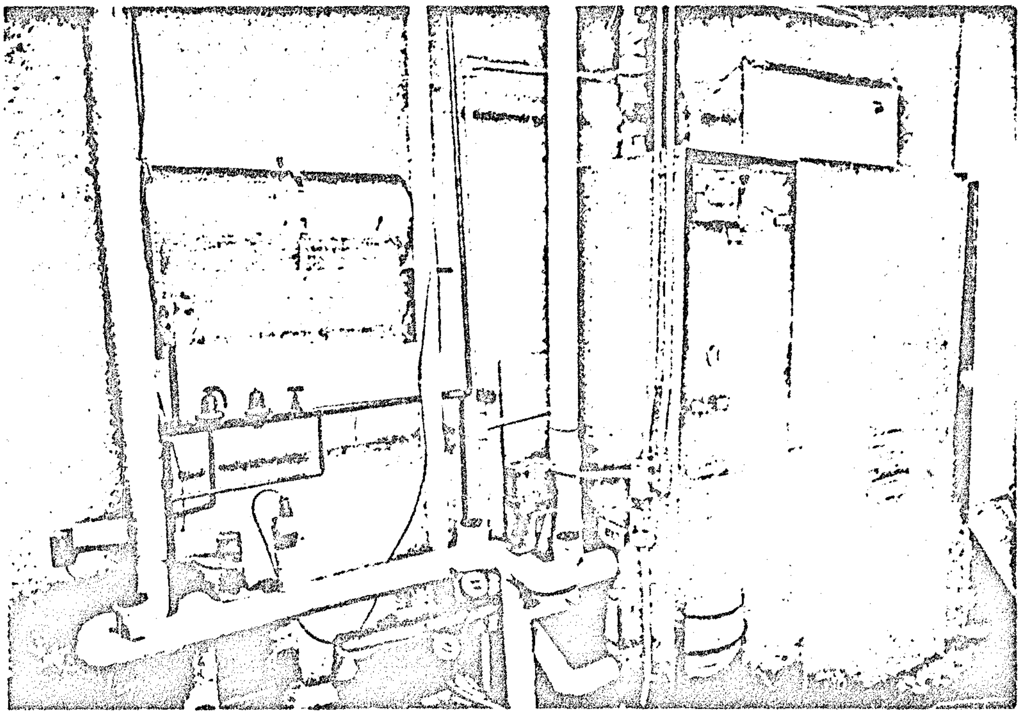

Fig. 3. Three-Ton Solar Air Conditioner

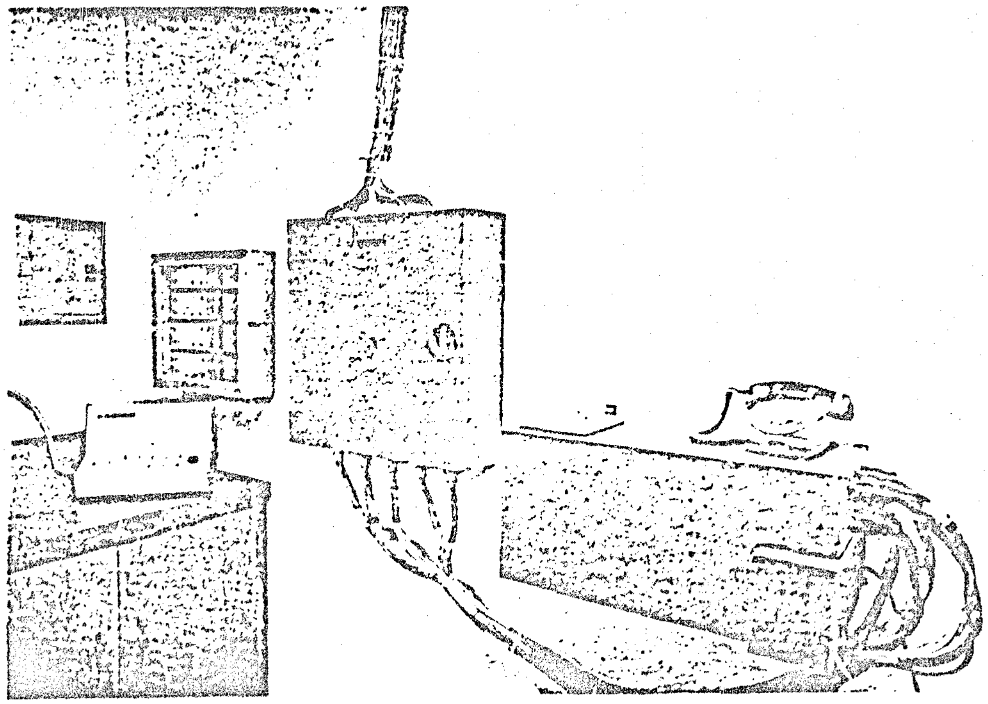

Fig. 4. Solar Control Panel, Temperature Controllers, Junction Box for Monitoring Sensors, and Data Acquisition System

RADIAN CORPORATION

ORIGINAL PAGE IS
OF POOR QUALITY

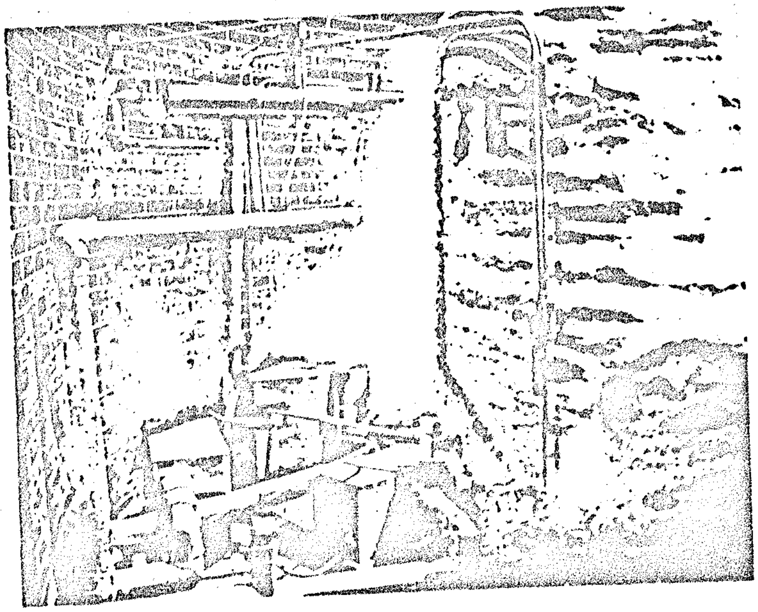

Fig. 5. 1500-Gallon Thermal Storage Tank and Circulating Pumps

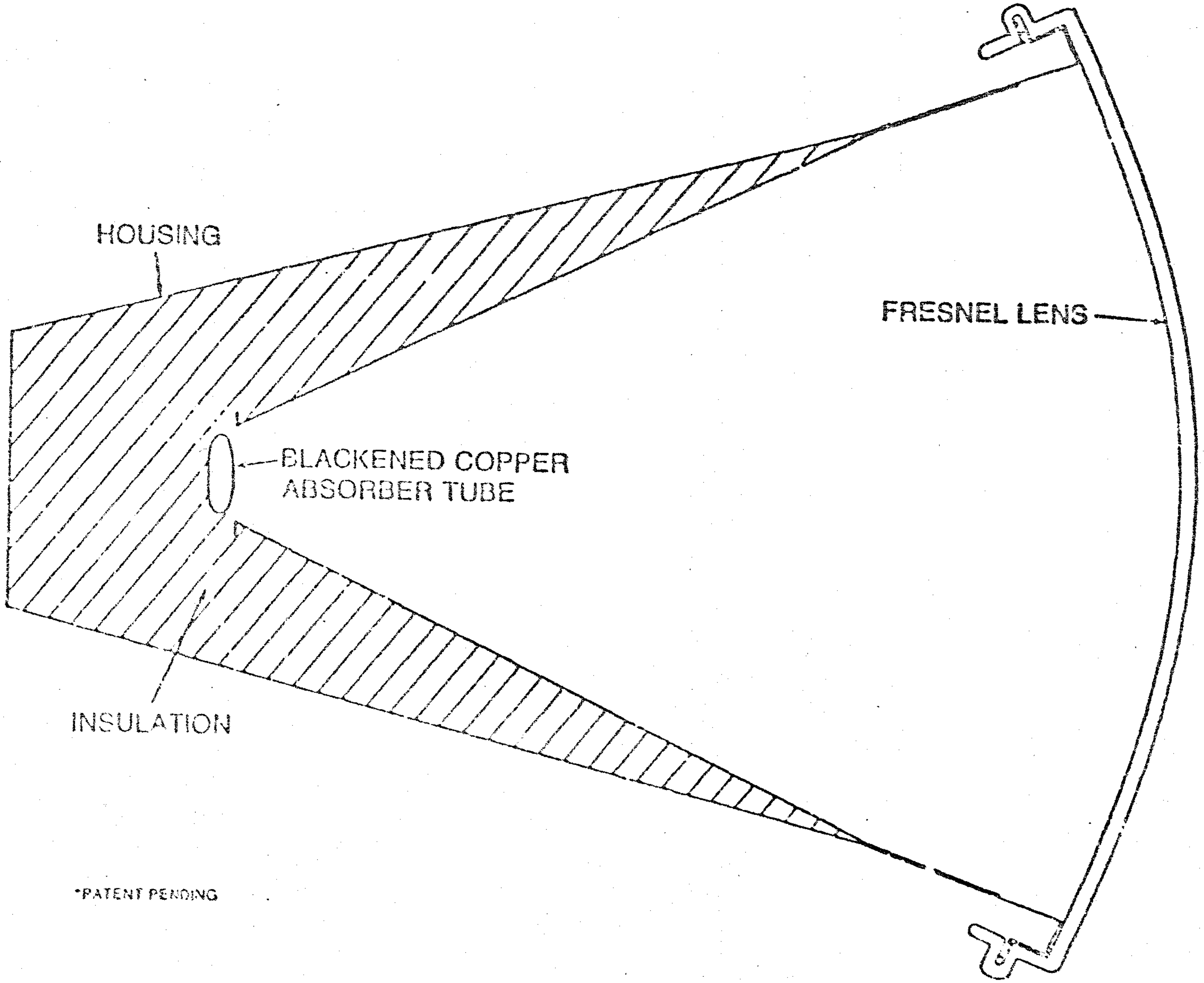

Fig. 6. Cross Section of Northrup Concentrating Collector

latitude) so that the collector's axis of rotation coincides with the polar axis of the earth.

Due to roof obstructions, Radian's 36 collectors are split into two banks; one containing 16 collectors and the other containing 20 collectors. The distance between banks is such that essentially no solar energy is lost due to shading. Figures 7 and 8 show the collector location on the roof and the shading analysis for December 21 As seen in Fig. 4, the shadow from the south bank leaves the collecting surface of the north bank by 7:30 A.M. solar time. Since December 21 is the day that the sun is at its southern most position, the shading analysis shown corresponds to the worst case.

The efficiency curve for the Northrup collector is presented in Fig. 9. The efficiency of the collector is shown in terms of the difference in the average collector temperature (TF) and the ambient temperature (TA) divided by the solar insolation (I). To make the abscissa scale more meaningful, and insolation of 300 Btu/hr sq ft and 75°F ambient air temperature are assumed and the efficiency is plotted as a function of average collector temperature. In the region above 150°F, the Northrup collector has a higher efficiency than most flat plate collectors. The high temperatures required for solar air conditioning with lithium bromide-water units (170°F to 240°F) gives the concentrating collectors a definite advantage over most flat plate collectors.

2.1.2 Thermal Storage Tank

The 1500 gal fiberglass storage tank is manufactured by Red Ewald, Inc. Since this tank can store water at temperatures up to 210°F, three inches of urethane foam are used to insulate

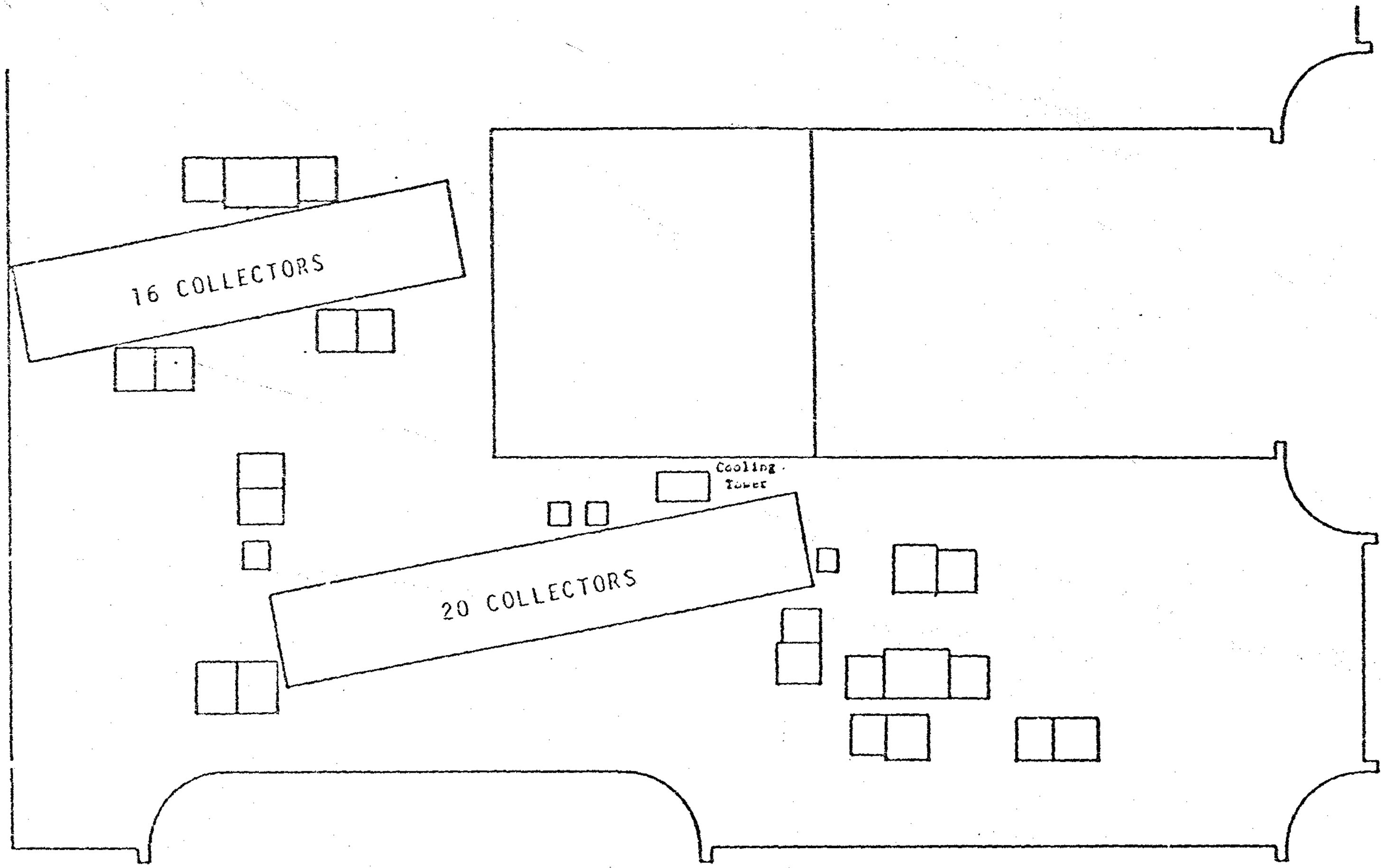

Fig. 7. Collector Layout

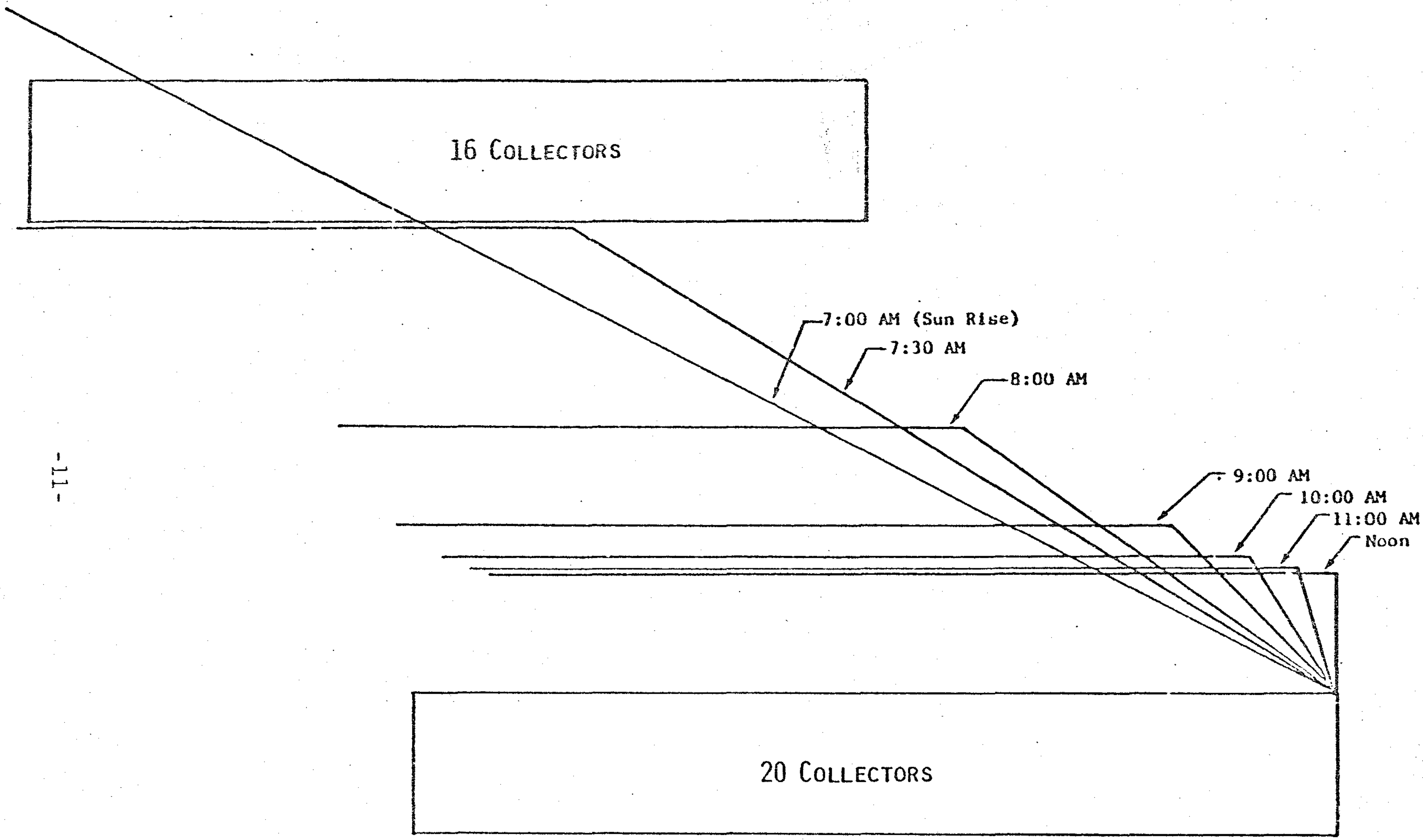

Fig. 8. Collector Shading for December 21

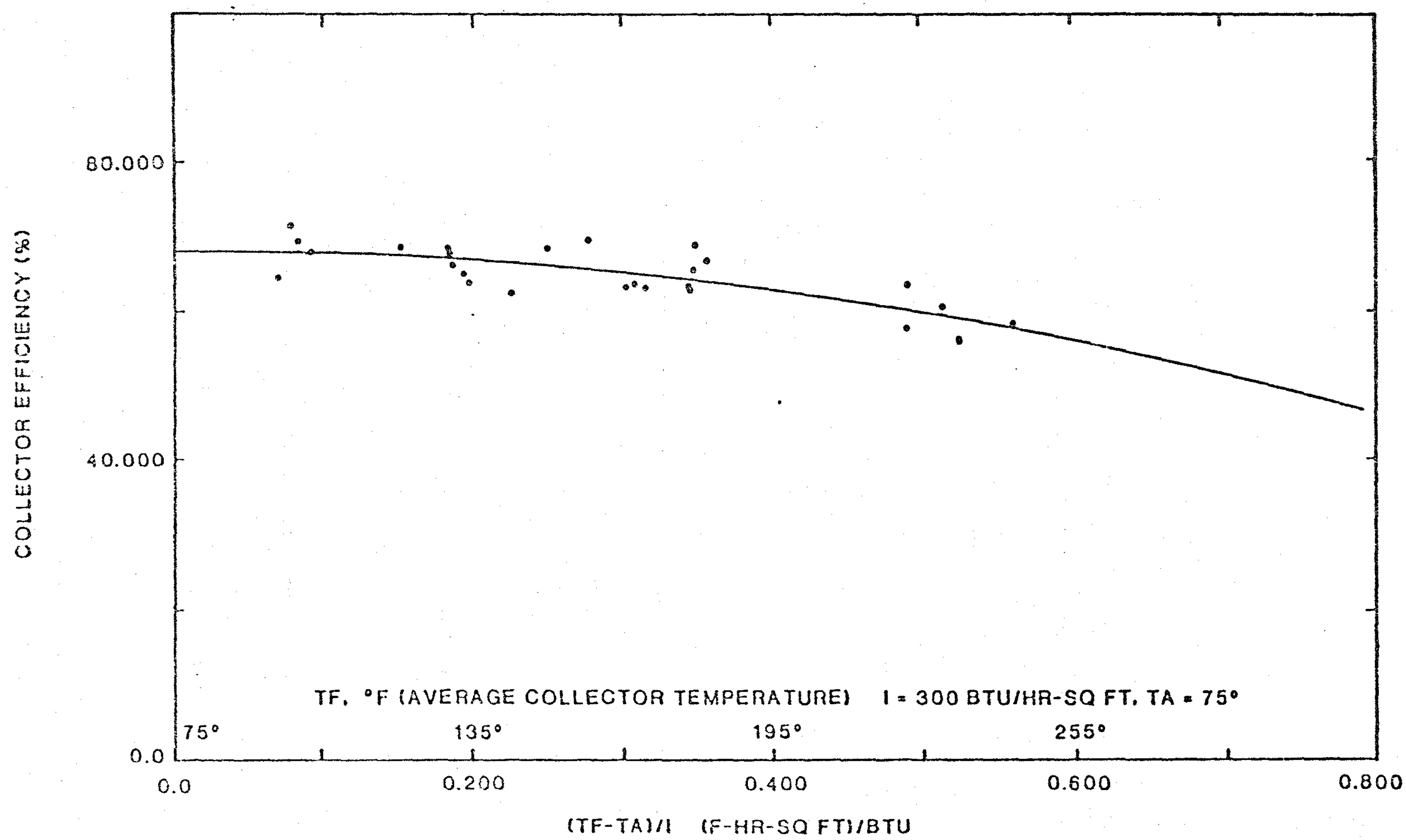

Fig. 9. Efficiency of Northrup Concentrating Collector

tank. This insulation is covered with a vinyl coating to weatherproof it. The vertical tank is 6 feet in diameter, 7 feet, 3 inches tall, and sets on a concrete slab. The total weight of the tank when filled is approximately 12,000 pounds. A covered manway, 24 inches in diameter, is provided at the top of the tank for easy access to the inside of the tank.

2.1.3 Solar Air Conditioner

Space cooling is provided by an ARKLA three-ton, lithium bromide-water air conditioner. This unit's cooling capacity is identical to the conventional backup unit and thus provides a one-to-one comparison of the unit's performance. The solar air conditioner requires 55,000 Btu/hr heat input with a hot water inlet temperature of 205°F to obtain the rated 36,000 Btu/hr cooling capacity. The cooling tower provides the air conditioner with approximately 80°F condensing water and rejects heat at a rate of 91,000 Btu/hr.

A simplified block diagram of the lithium bromide-water absorption unit is shown in Fig. 10. The solar heated water is circulated through a coil in the generator and is used to boil the water in the lithium bromide-water solution. Since the lithium bromide-water solution is under a partial vacuum, the water can be vaporized at temperatures well below 210°F. The boiling drives the concentrated lithium bromide solution (absorbent) and the water vapor (refrigerant) into the separator. In the separator, the water vapor is separated from the concentrated solution. The water vapor is then condensed by passing the vapor over the cool condenser coils. The pressure in the condenser and generator is approximately 50 mm of mercury while the pressure in the evaporator and absorber is approximately 7 mm of mercury.

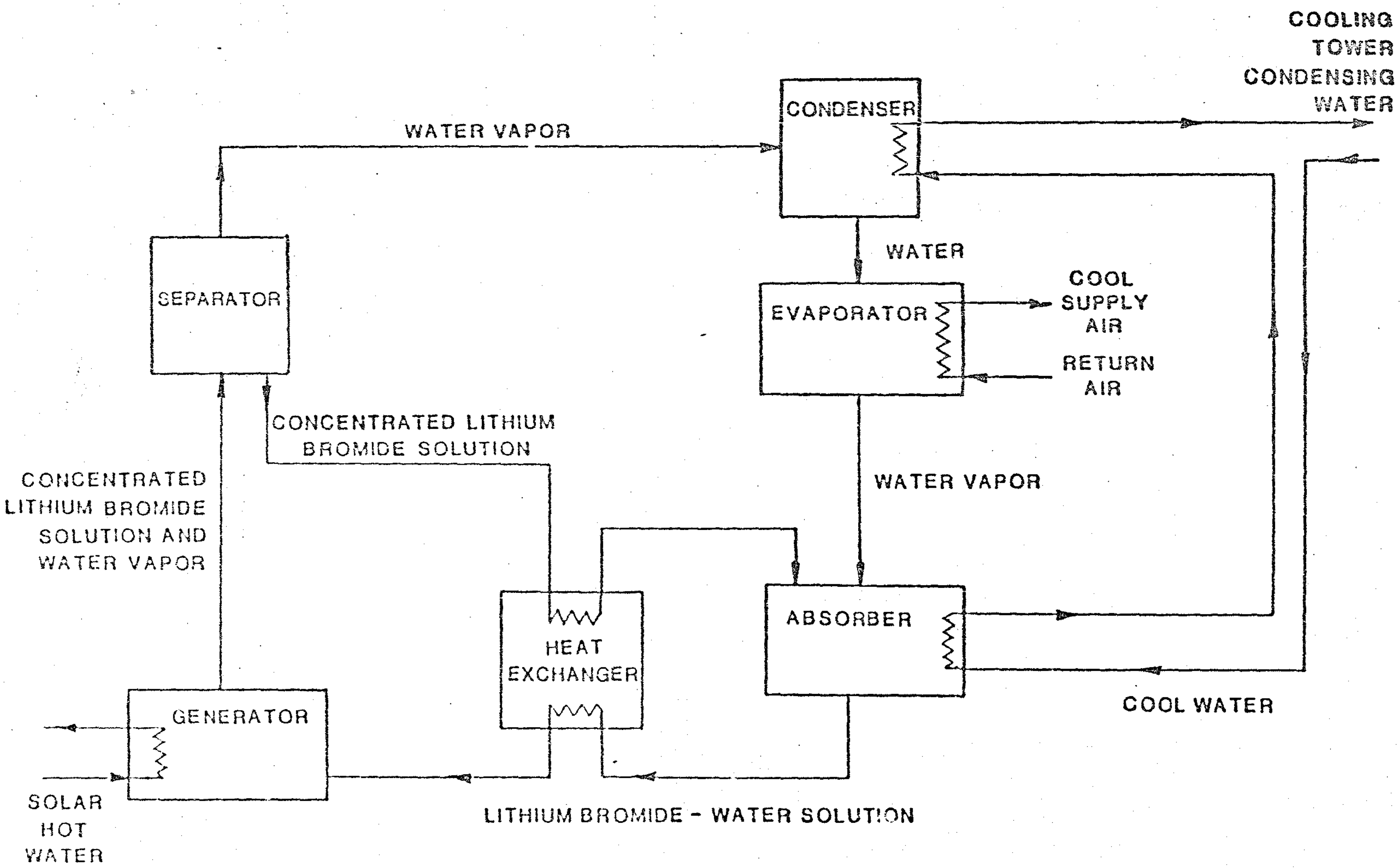

Fig. 10. Simplified Block Diagram of Lithium Bromide-Water Absorption Unit

02-1246-1

An orifice between the condenser and the evaporator provides a pressure barrier and thus maintains a higher pressure on the water in the condenser. As the water from the condenser passes through this orifice, it evaporates due to the reduced pressure and extracts heat from the air passing through the cooling coil (evaporator). Thus, the room air is cooled and dehumidified.

The water vapor leaves the evaporator and is absorbed by the concentrated lithium bromide solution in the absorber. The concentrated lithium bromide solution has a strong affinity for water vapor. This affinity is enhanced at lower temperatures. Two methods are used in the ARKLA unit to reduce the temperature of the hot lithium bromide solution from the separator. First, this hot solution passes through a heat exchanger where heat is transferred to the lithium bromide-water solution that is entering the generator. Second, the cool water from the cooling tower is passed through a coil in the absorber to further reduce the temperature.

After the absorption of the water vapor, the lithium bromide-water solution passes through the heat exchanger and enters the generator; thus completing the cycle.

While most absorption cooling units have solution pumps that circulate the lithium bromide-water solution, ARKLA's model 501-WF cooling unit does not utilize a pump. The flow within these units is maintained by the differential pressure created by boiling the refrigerant in the generator and by absorbing the refrigerant in the absorber.

2.1.4 Solar Heating Coil

Solar space heating is accomplished by circulating hot water through an ARKLA-Servel DCH 36-90 duct coil. The fan in the ARKLA air conditioner blows the room air through this coil and thereby heats the room. This heating coil is rated at 90,000 Btu/hr with an inlet water temperature of 175°F, water flow at 7.2 GPM, and an air flow of 1200 CFM. This heating capacity also matches the conventional unit capacity.

2.1.5 Heat Exchanger

The copper heat exchanger was custom built by Packless Industries, Inc. With the specified conditions listed below, the heat exchanger will transfer 60,000 Btu/hr.

- Hot water flow rate: 14.5 GPM
- Hot water inlet temperature: 210°F
- Hot water outlet temperature: 201.5°F
- Fluid: 50% ethylene glycol-water
- Maximum pressure drop at 14.5 GPM: 3.5 psi
- Cold water flow rate: 25 GPM
- Cold water inlet temperature: 180°F
- Cold water outlet temperature: 185°F
- Fluid: water
- Maximum pressure drop at 25 GPM: 3.5 psi.

The approximate dimensions of this heat exchanger are 4 feet by 9 inches by 2 inches.

2.1.6 Pumps

All four centrifugal pumps used in Radian's solar system are Bell and Gossett Series 1522. Pumps 1 and 2 (see Fig. 1) consist of 3/4 AAB pumps and 1/3 horse power motors, while pumps 3 and 4 consist of 3/4 AAB pumps and 1/4 horsepower motors. All of the pumps have a full 5-1/4 inch impeller. Pumps 1 and 2 provide 26.3 feet of head (11.4 psi) at 15 GPM, while pumps 3 and 4 provide 28.5 feet of head (12.4 psi) at 10 GPM.

2.1.7 Conventional Backup Unit

The conventional backup unit is a Lennox model GCS6-413-120A. This unit has an electric air conditioner and a gas heater. The conventional and the solar air conditioning units are equipped with separate supply ducts. However, the common return duct is used to ensure that the return air temperature is the same for both units.

2.2 System Controls

The solar system controls consist of a dual-stage thermostat, a control panel, a differential temperature controller, and three absolute temperature controllers. The Honeywell dual-stage thermostat is used to provide both the solar system and the conventional system with heating and cooling demands. Stage 1 of the thermostat controls the ARKLA unit while Stage 2 controls the Lennox unit. As the room temperature rises with the thermostat set in the cooling mode, the ARKLA unit will turn on first if the generator inlet temperature is above 190°F. If the ARKLA unit cannot fully supply the cooling load and the room temperature continues to rise an additional 3°F, the Lennox unit will turn on providing backup cooling. The Lennox unit will turn off when the room temperature drops 3°F. The solar air conditioner will continue to operate until the room temperature has dropped an additional 3°F.

Space heating operates in a similar manner. The solar heater will be the first to turn on. If the room temperature continues to drop an additional 3°F, the Lennox furnace will provide backup heating.

Switches located on the control panel allow either unit to be turned on or off independently. Thus, operation of the solar system by itself or operation of the conventional system by itself is also possible.

Since the ARKLA unit requires a minimum generator inlet water temperature of 190°F, a temperature controller is used to prevent operation of the solar air conditioner if the hot water temperature is below this minimum. Similarly, a temperature controller is used to prevent solar heater operation when the hot water supply to the heating coil is below 100°F. This controller prevents unnecessary energy consumption by the circulating pumps and fan when the hot water temperature is so low that little or no solar space heating is realizable.

The third temperature controller is used to limit the maximum collector temperature. A temperature sensor, located on the surface of a collector absorber tube, provides the input to this controller. Whenever this temperature rises above 220°F, the collectors are automatically defocused by overriding the tracking controls and rotating the collectors back towards the east. As the temperature drops back down to 215°F, the collectors are again allowed to track the sun. During the defocusing period, an alarm is sounded and an LED is illuminated on the control panel. While the alarm can be silenced, the LED will remain illuminated until this over-temperature condition is rectified. This controller prevents the excessive collector temperatures that could be encountered under no flow conditions. (The absorber tubes can be permanently damaged if their temperature is allowed to exceed 500°F.) The maximum temperature of the system's working fluid is also limited to 220°F. This prevents the pressure relief valve from relieving working fluid due to high pressure that is caused by excessive fluid temperatures in a closed system.

A differential temperature controller is used to sense a positive differential temperature between the collector outlet water and the storage tank water. When the collector outlet temperature is 10°F hotter than the storage tank water temperature, pumps P1 and P2 are turned on. These pumps remain on until the differential temperature drops below 1°F. At this time the pumps will turn off and will not turn on until the differential temperature again exceeds 10°F. A time delay relay is also incorporated into this controller to prevent excessive cycling during the morning start-up period. After the pumps turn on, they will remain on for at least five minutes regardless of the temperature differential.

One other safety feature included in the Radian-built control system is a low water alarm. This alarm sounds and an LED on the control panel is illuminated whenever the water level in the storage tank drops below a set level. This alarm indicates a malfunction in the water make-up valve. The alarm will automatically silence when the proper water level is restored.

2.3 Modes of System Operation

While most solar systems have only one or .wo modes of operation, Radian's system was designed to operate in a number of modes and to permit evaluation of each. With this design, Radian will be able to fully evaluate the performance of the solar system and the Company plans to use the system as a test bed for new components.

Figure 11 shows the collectors heating the storage tank water. In this mode of operation, the storage tank water is circulated through the collectors. Since the storage tank is vented to the atmosphere, pumps P1 and P2 provide sufficient pressure to overcome the static head and the head loss due to friction at the rated flow of 14.5 GPM.

The collectors can also heat the storage tank water using the heat exchanger. Figure 12 illustrates this mode of operation. The collector-heat exchanger loop is now a closed system, and therefore pump P2 must only provide sufficient pressure to overcome the head loss due to friction at the 14.5 GPM flow rate. Pump P1 circulates the storage tank water through the counter flow heat exchanger. The flow rate for this loop is 25 GPM. In this mode ethylene glycol and water can be used in the collector loop for freeze prevention. While the use of the heat exchanger does reduce the system's overall efficiency a little, the addition of 750 gallons of ethylene glycol to the storage tank would be extremely expensive.

When a cooling demand exists and the storage tank water temperature is above 190°F, pumps P3 and P4 circulate the tank water through the ARKLA absorption unit as shown in Fig. 13. Condensing water is also circulated through the ARKLA unit and the cooling tower.

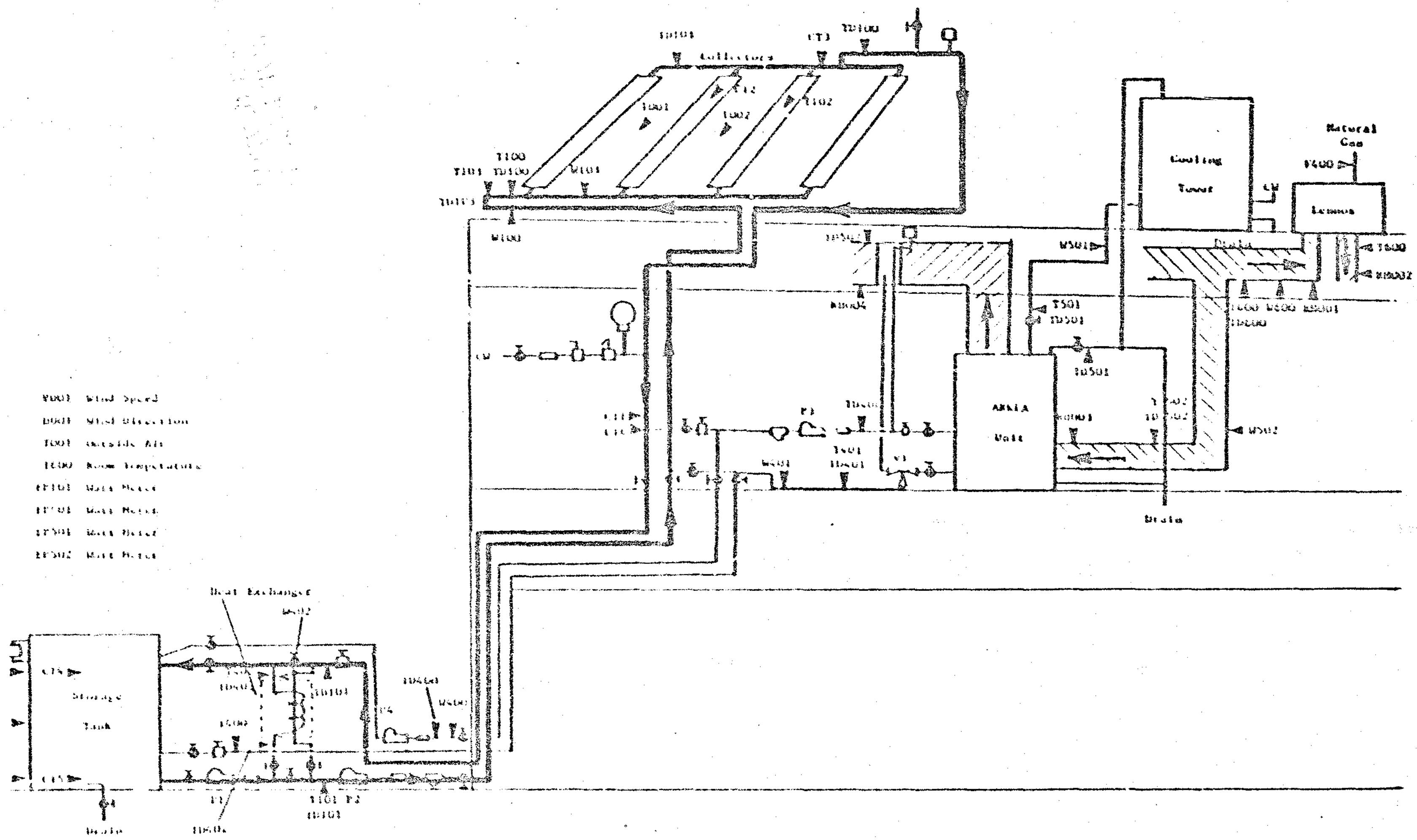

Fig. 11. Radian Corporation Solar Demonstration Project Flow Diagram and Monitoring Sensor Locatic ; (Collector-Storage Tank)

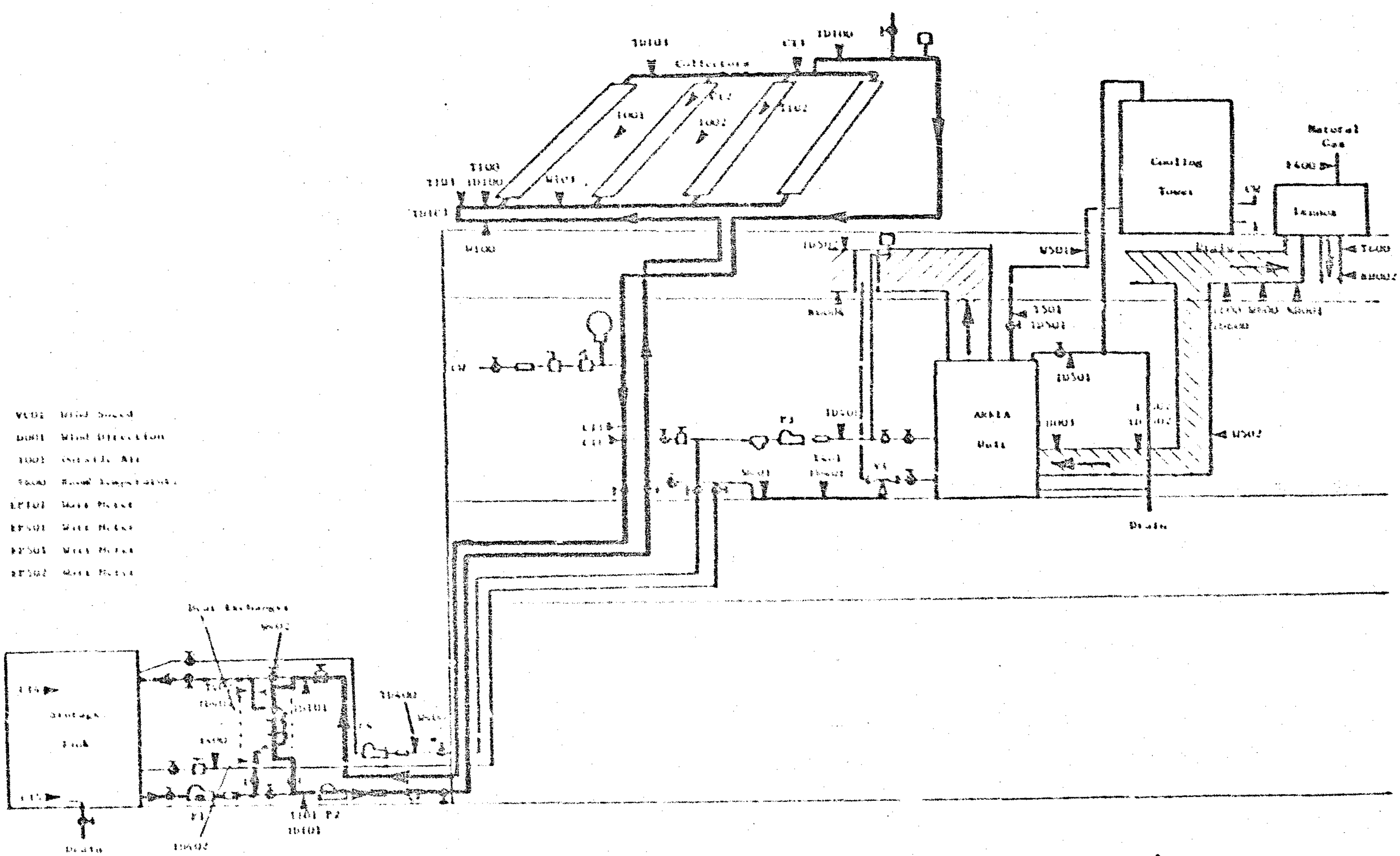

Fig. 12. Radian Corporation Solar Demonstration Project Flow Diagram and Monitoring Sensor Location (Storage Tank-Heat Exchanger-Collector Mode)

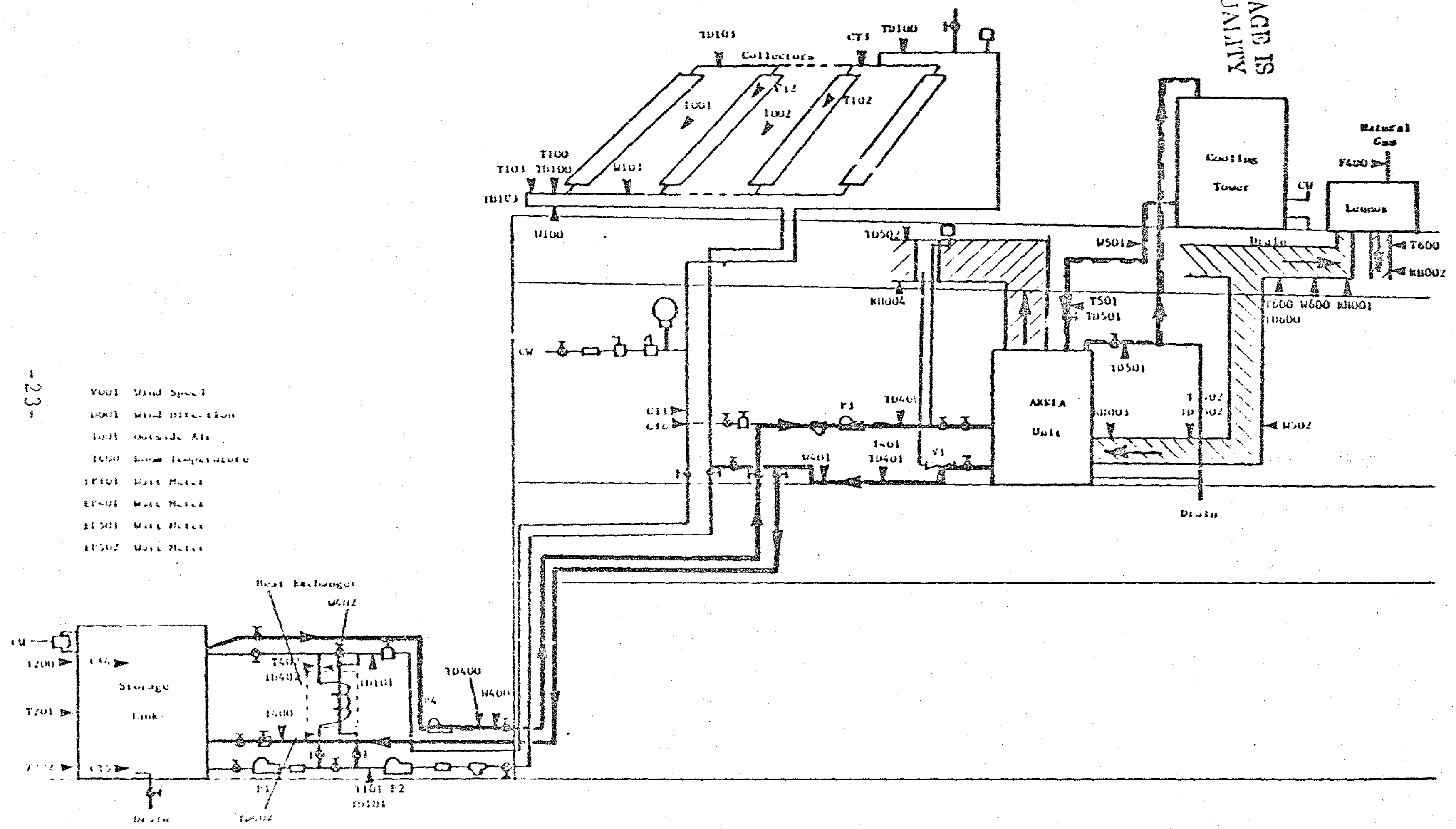

Fig. 13. Radian Corporation Solar Demonstration Project Flow Diagram and Monitoring Sensor Location (Storage Mode, Air Conditioning)

When space heating is required, the storage tank water is circulated through the heating coil as shown in Fig. 14. The automatic three-way valve (V1) sends the flow to either the heating coil or the ARKLA unit. The flow rate for this loop is 11 GPM.

The solar system can also be operated in a direct mode which bypasses the storage tank. Figure 15 shows how the water is circulated for cooling in the direct mode. Since this is a closed or sealed loop, pump P3 can provide sufficient pressure to match the frictional head loss at 11 GPM. The cooling tower fan and pump are again turned on to provide condensing water for the ARKLA unit.

Heating in the direct mode is shown in Fig. 16. The three-way valve directs the water flow through the heating coil and to the collectors. The fan in the ARKLA unit is again used to circulate room air through the heating coil.

2.4 System Performance Monitoring

The performances of the solar system and the conventional heating and cooling unit are monitored using 47 sensors. The locations of these sensors are shown in Fig. 1. The types of sensors and their alphanumeric identification are given below.

T - Absolute Temperature
TD - Differential Temperature
W - Liquid or Air Flow
I - Diffuse or Total Insolation
EP - Wattmeters
V - Wind Speed
D - Wind Direction

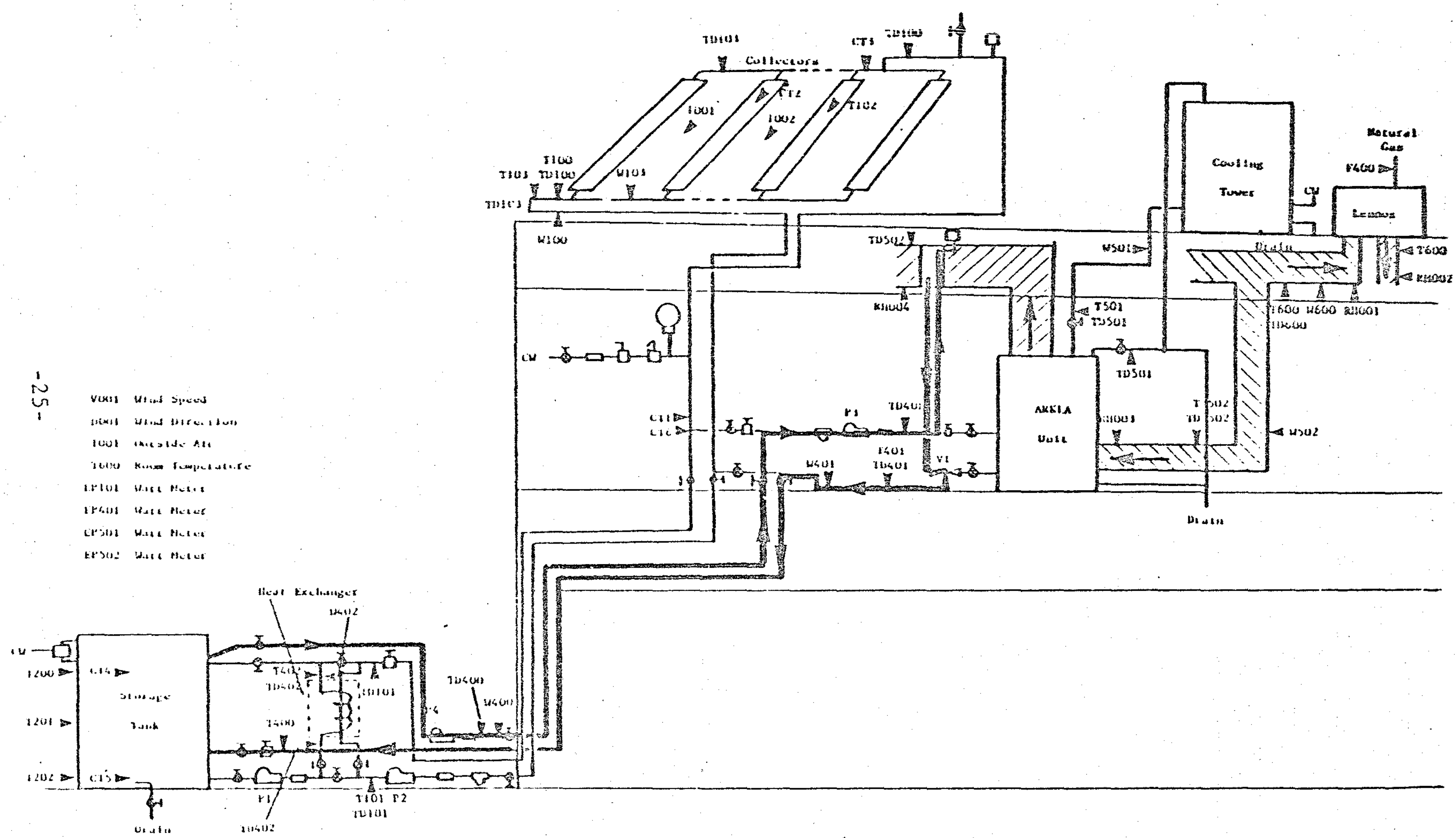

Fig. 14. Radian Corporation Solar Demonstration Project Flow Diagram and Monitoring Sensor Location (Storage Mode, Heating)

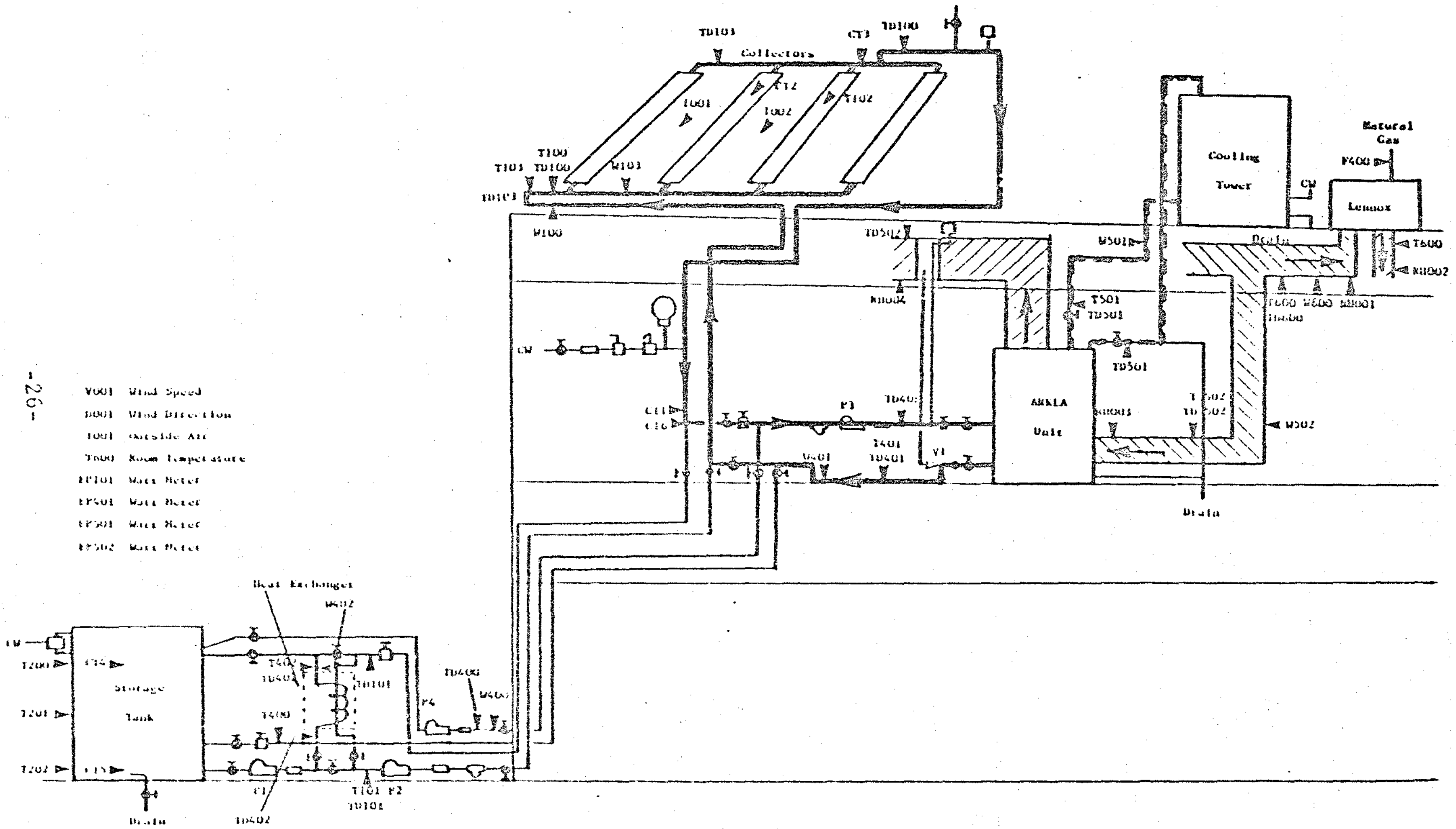

Fig. 15. Radian Corporation Solar Demonstration Project Flow Diagram and Monitoring Sensor Location (Direct Mode, Air Conditioning)

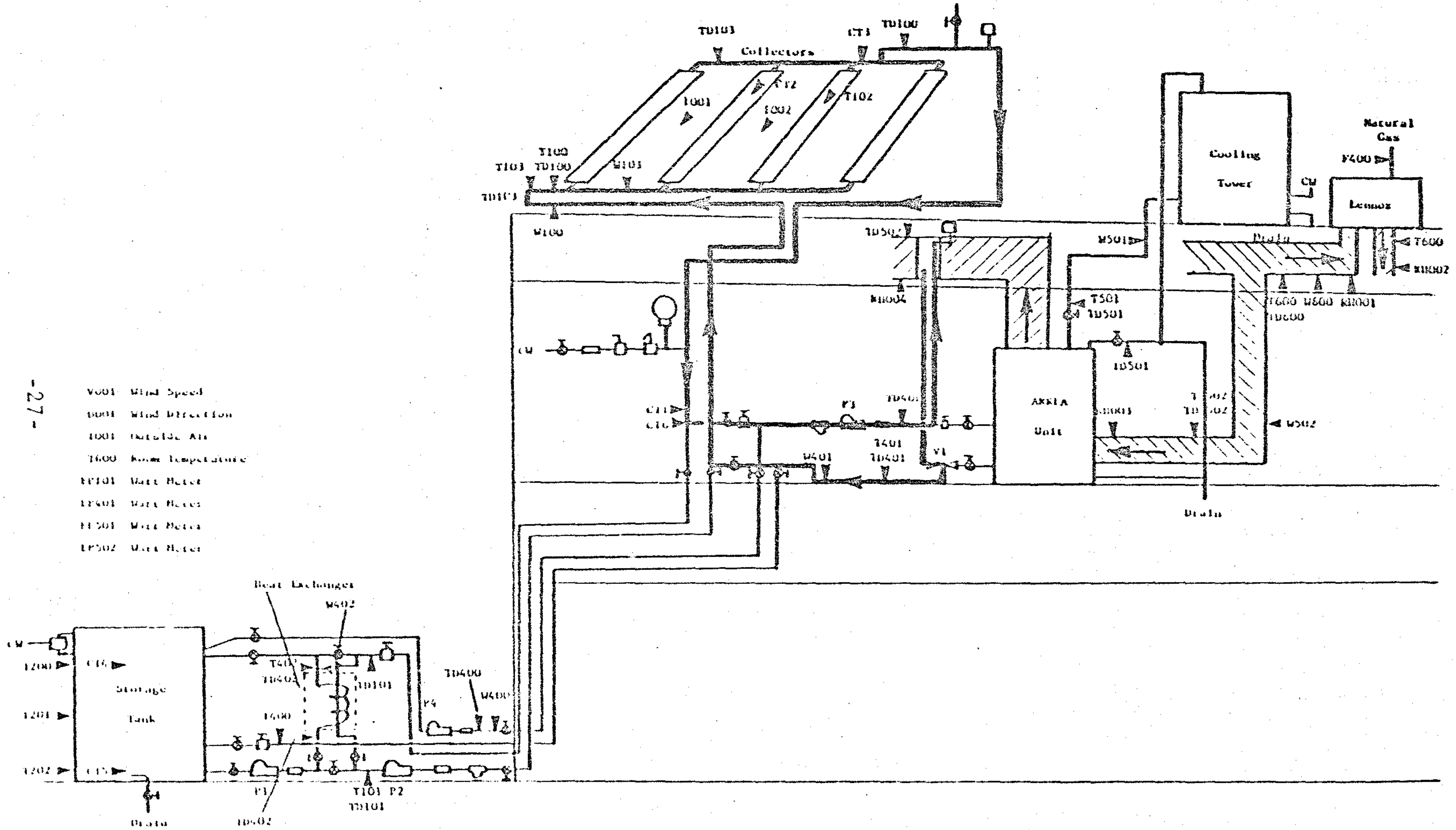

Fig. 16. Radian Corporation Solar Demonstration Project Flow Diagram and Monitoring Sensor Location (Direct Mode, Heating)

F - Totalizing Gas Flow
RH - Relative Humidity
CT - Control Temperature

The outputs of these sensors are sampled once every five minutes by a data acquisition system and recorded on a cassette tape recorder.

An on-site-monitor that plugs into the on-site data acquisition system provides a real time display of any sensor output. In addition to serving as a valuable system checkout device, the on-site-monitor also allows instantaneous testing and evaluation of new system components.

2.5 Display Board

Radian has constructed three-foot by five-foot display board depicting the solar heating and cooling system. Six temperatures are displayed along with a flow diagram of the system. The temperatures, the storage tank temperature, the hot water supply temperature for the ARKLA unit or the heating coil, the condensing water temperature, and the ARKLA supply duct air temperature. The modes of operation can be demonstrated by illuminating the flow paths for a particular mode. Switches located on the display board allow selection of a demonstration of the following modes of operation.

1) Heating or Cooling Directly from Collectors,

2) Heating or Cooling by the Hot Water Storage Tank,

3) Heating or Cooling by the Conventional Unit,

4) Collector Heating of the Hot Water Storage Tank, and

5) Collector Heating of the Hot Water Storage Tank Using the Heat Exchanger.

3.0 COMPONENT AND INSTALLATION COSTS

The costs of the solar system are divided into several subsystems or work areas. Some of these costs include subcontract costs and therefore more detail on some categories is not possible. The detailed costs of each of the following categories are presented in the sections below.

- Collectors and Framework
- Storage Tank
- Heating and Cooling Subsystem
- Controls
- Piping, Pumps and Insulation
- Electrical Wiring
- Display Board
- Miscellaneous

3.1 Collectors and Framework

This category includes the cost of the 36 concentrating collectors including the tracking mechanisms and framework. The cost of installing the collectors and framework are also included.

Item	Cost
36 Collectors	$ 8,315
Tracking System	830
Framework	2,600
Freight	145
Installation of Collectors	465
Installation of Framework	1,500
Total	$13,855

3.2 Storage Tank

This category includes the cost for the storage tank installation, site preparation, and freight.

Item	Cost
1500 Gal. Storage Tank	$ 785
Urethane Insulation	300
Site Preparation (slab)	400
Freight	50
Installation	175
Total	$1,940

3.3 Heating and Cooling Subsystem

This category includes the costs for the solar heating and cooling system components. The cost of ducting and the cost of positioning the air conditioner on the second floor are also included.

Item	Cost
ARKLA Air Conditioner	$3,000
Heating Coil	170
Cooling Tower (used)	375
Freight	80
Positioning Air Conditioner	120
Ducting	610
Total	$4,355

3.4 Controls

This category includes all of the sensors, controllers, and control panel needed to provide automatic operation and safety controls.

Item	Cost
Control Panel and Sensors	$1,865
Wiring (subcontract)	65
Total	$1,930

3.5 Piping, Pumps and Insulation

This category includes the cost of valves, piping, pumps, heat exchanger and insulation excluding the insulation for the storage tank.

Item	Cost
Pumps, Valves, Heat Exchanger	$1,320
Water Treatment System	325
Plumbing Subcontract Including Pipes, Cutoff Valves, Installation, Labor, and Labor for Insulation of Pipes	5,080
Insulation Including Aluminum Weatherproof Covering	1,210
Labor for Insulation of Valves and Pumps	525
Total	$8,460

3.6 Electrical Wiring

The costs of conduit, power wiring for pumps, collector tracking mechanism and air conditioner wiring and labor for installation of these items are included in this category.

Item	Cost
Electrical Subcontract	$710
Total	$710

3.7 Display Board

The display board was totally designed and built by Radian. This item is not essential to the operation of the solar system.

Total	$7,726

3.8 Monitoring Sensors and Installation

This category is for monitoring system sensors only. These items are not essential for the operation of the solar system.

Item	Cost
Sensors	$ 9,710
Installation	3,344
Total	$13,054

3.9 Engineering Design and Installation Supervision

Total	$10,832

3.10 Miscellaneous

This category includes items such as trips to attend conferences and working sessions on the tracking mechanism problems, minor modifications to the tracking me hanisms, etc.

Total	$ 2,515

3.11 Summary of Costs

The cost for items that are essential to the operation of the system are separated below from those that are not essential to the system operation. The costs for design and installation supervision are included in the essential costs since some design time and installation supervision will be necessary on any system. However, the costs for these services are greatly reducing as more experience is gained from additional installations.

Essential Costs

Collectors and Framework	$13,855
Storage Tank	1,940
Heating and Cooling Subsystem	4,355
Controls	1,930
Piping, Pumps and Insulation	8,460
Electrical Wiring	710
System Design and Installation Supervision	10,832
Total	$42,082

Non-Essential Costs

Display Board	$ 7,726
Monitoring Sensors and Installation	13,054
Miscellaneous	2,515
Total	23,295
TOTAL COSTS	$65,377
Department of Energy Funding	$56,823
Radian Contribution	$ 8,554

4.0 OTHER REPORTS

Available from the National Technical Information Center, P. O. Box 62, Oak Ridge, Tennessee, 3``30.

4.1 MONTHLY PERFORMANCE REPORTS

These reports document pertinent information on the Thermal Performance, System Operation and General Status of the Solar Energy System for the reporting period.

DATE	REPORT NUMBER
September, 1977	SOLAR/2002-77/09
October, 1977	SOLAR/2002-77/10
December, 1977	SOLAR/2002-77/12
January, 1978	SOLAR/2002-77/01
February, 1978	SOLAR/2002-77/02
March, 1978	SOLAR/2002-77/03
April, 1978	SOLAR/2002-77/04
May, 1978	SOLAR/2002-77/05
June, 1978	SOLAR/2002-77/06
July, 1978	SOLAR/2002-77/07
August, 1978	SOLAR/2002-77/08
September, 1978	SOLAR/2002-77/09
October, 1978	SOLAR/2002-77/10
November, 1978	SOLAR/2002-77/11
December, 1978	SOLAR/2002-77/12
January 1979	SOLAR/2002-77/01

4.2 PERFORMANCE EVALUATION REPORT

This report presents Thermal Performance Data from the Monthly Performance Reports in a more comprehensive manner. It contains tabulated Monthly Data, extracted from the Monthly Performance Reports. These data include Measured Weather Data

Versus Long-Term Average Weather Data, System and Subsystem Energy Flows and Effeciencies, System and Subsystem Operating Energy Requirements and Energy Savings.

DATE	REPORT NUMBER
September, 1977 thru May, 1978	SOLAR/2002-78/14

4.3 SOLAR PROJECT DESCRIPTION REPORT

This report is prepared for each instrumented Commercial Solar Energy System. It is published when the first Solar Energy System Performance Evaluation Report is published for the corresponding project. Its purpose is to document the "as-built" configuration of the Monthly Performance Reports and Solar Energy System Performance Evaluation Reports.

DATE	REPORT NUMBER
May 2, 1978	SOLAR/2002-78/50

4.4 SOLAR PROJECT COST REPORT

This report is prepared for each instrumented Commercial Solar Energy System. The report is generally published simutaneously with the corresponding Solar Project Description Report.

DATE	REPORT NUMBER
May 2, 1978	SOLAR/2002-78/60

☆U.S. GOVERNMENT PRINTING OFFICE: 1980-640-247/567 REGION NO. 4

END

DATE

FILMED

AUG 8 1980

End of Document